Introduction to Futures Contracts

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Abstract

Futures contracts are widely utilized throughout the investment universe, but not always understood. The following paper covers the fundamentals of futures contracts. In particular, the mechanics, pricing, use and risks of future contracts are examined. The appendix contains a more theoretical discussion of how to price futures contracts.

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What are Futures?

Most investors are familiar with spot markets, public markets where financial instruments are purchased for cash and then delivered immediately. The stock market is a spot market; investors pay cash, and receive a stock. There are commodities spot markets, such as the markets for gold and oil, where physical bars of gold or barrels of oil can be purchased for cash. In addition to cash (spot) markets, there are also *derivatives* markets, so-called because prices are "derived" from an underlying asset. The two major types of derivatives are commodities derivatives, prices of which are based on physical commodities, and financial derivatives, prices of which are based on financial assets. Common derivatives include futures contracts and forward contracts. As their names imply, futures and forwards are agreements to buy or sell an underlying asset in the future.

Whereas in the cash markets a barrel of oil is purchased for consumption today, in the futures and forwards markets an agreement is entered into to purchase oil at some point in the future. A *forward* is a customized over the counter (OTC)[1] contract between two parties, while a *future* is a standardized agreement traded on an exchange. There are two sides to every future or forward contract, a long and a short. The long is the purchaser of the contract, and profits as the underlying asset increases in value. The short is the seller of the contract, and profits as the underlying asset decreases in value.

The major differences between futures and forwards are customization, liquidity, and counterparty[2] risk. Because forward contracts are custom OTC agreements, they are subject to both liquidity risk (the risk they will be difficult to sell), and counterparty risk (the risk the counterparty on the other end of the contract won't pay). In contrast, futures contracts are standardized and traded on exchanges. Because they are exchange traded, futures contracts are more liquid than forward contracts. Additionally, a feature of futures exchanges is a central clearinghouse that clears and settles all trades and collects margin. Margin is settled daily; every day, the increase or decrease in market value is posted to the investor's margin cash. The clearinghouse acts as an intermediary between all trades to match orders. The clearinghouse buys every contract sold, and the clearinghouse sells every contract bought. For these reasons, futures investors are exposed to significantly less[3] counterparty risk than forward investors.

There are some basic features common to all futures contracts:

- The contracts are based on an underlying asset. Examples include commodities, like corn or oil, or financial assets like currencies.
- The contracts have a settlement date or delivery date; this is the date of the contract's expiration. Settlement can be in cash, or delivery of the underlying asset.
- The contracts are based on a specific size of the underlying asset, or the amount of the underlying the contract is based on. For example, the contract size of wheat futures is 5,000 bushels[4].
- Various contract specifications that depend on the underlying, e.g. the type or quality of wheat, or what bonds can be delivered.

1 Over the counter instruments are traded directly between parties, off exchanges

2 When referencing a financial derivative, the counterparty is the entity on the opposite side of the contract

3 Investors are protected both by posted margin, and by the clearinghouse acting as an intermediary between counterparties. To date, no major clearinghouse has defaulted.

4 Source: CME Group margin rates

In summary, while both futures and forwards contracts are similar, forward contracts are customizable and traded OTC while futures contracts are standardized and exchange traded. However, because forwards are customizable and lack margin requirements they are exposed to greater risk.

Futures and Margin

An important feature of futures trading is the available leverage[5]. When an investor agrees to purchase a futures contract, he is required to put down cash collateral, called *initial margin*. Since the minimum initial margin for most futures contracts ranges between 5-15% of the value of the futures contract, it is possible to apply significant leverage to futures positions. Futures contracts are settled daily, so if the price of, for example, wheat increases, the long investor will see an increase in margin cash, and if the price decreases a corresponding decrease in cash. Futures accounts are settled in cash daily, and the change in margin is called the *variation margin*. Margin is required to be above a set level, called *maintenance margin*. If margin drops below this level, the investor will be forced into a *margin call*, to add cash to the account to increase equity above the maintenance margin.

As an example of the use of margin (illustrated below in Exhibit 1), suppose an investor decides to go long wheat at $3.00 a bushel. As each contract is for 5,000 bushels, the initial value of the futures contract is $15,000. Initial margin for wheat is $1,350[6]. If the investor posts the minimum initial margin of $1,350 on a $15,000 contract, he is effectively leveraged more than ten times. If the price of wheat subsequently rises from $3.00 a bushel to $3.03 a bushel, the price of the futures contract will increase to $15,150 for a profit of $150. While the wheat contract earned a 1% return, the return on invested capital is 11% ($150 / $1,350) with margin leverage.

Suppose the investor keeps the long wheat position open. Margin is now $1,500 due to the daily cash settlement, and the price of the wheat futures contract is $15,150. If the price of wheat drops from $3.03/bushel to $2.94/bushel, the new price of the futures contract is $14,700, a $450 dollar loss. The return on the futures contract is -2.97%, but the return to the leveraged investor is -30%.

Exhibit 1: Futures Leverage Example

Day	Initial Price per Bushel	Initial Futures Value	Starting Margin	New Price per Bushel	New Futures Value	Futures Return	Invested Capital Return
1	$3.00	$15,000	$1,350	$3.03	$15,150	$150 / $15,000 = 1%	$150 / $1,350 = 11%
2	$2.94	$15,150	$1,350 + $150 = $1,500	$2.94	$14,700	-$450 / $15,150 = -3%	-$450 / $1,500 = -30%
3	$2.91	$14,550	$1,500 - $450 = $1,050	$2.91	$14,550	-$150 / $14,700 = -1%	-$150 / $1,050 = -14%

What happens if the price of wheat keeps dropping? In the example in Exhibit 1, on day 3 the price of wheat has dropped another $.03 to $2.91/bushel, resulting in a $150 dollar loss. Again the negative returns are magnified by leverage, as the futures contract has a return of -1.02% while the return on invested capital is -14.29%.

[5] Leverage is the ability to amplify returns as well as risk. Leverage can be obtained in the stock market by borrowing money to purchase stocks. Margin in the futures market is used as collateral. To obtain leverage, an investor would post an amount of collateral less than the total position size.

[6] Source: CME Group margin rates

Additionally, because margin has decreased below the maintenance margin level of $1,000[7], the investor is now facing a margin call, and will be forced to provide an additional $100 cash margin.

Clearly, while the use of leverage can magnify gains, it can also magnify losses. It is important to note that just because large amounts of leverage are available in futures markets, doesn't mean leverage has to be used. Popular commodities indices, such as the S&P Goldman Sachs Commodity Index, are fully collateralized[8].

Pricing Future Contracts

Pricing of futures contracts is based on the principle of efficient markets; there should be no arbitrage available. The no arbitrage condition means that two financial instruments that are identical should trade at the same price, otherwise a risk free profit, or arbitrage would be available. If such an opportunity was available, arbitrageurs would quickly exploit price differences between markets thereby bringing prices back to parity. Therefore, the price of a futures contract, or agreement to purchase an asset in the future, should be equal to the price of buying the asset now, plus any costs of buying in the spot market, minus any benefits.

Futures Price = Price of Underlying – Benefits + Costs

One of the most obvious differences between purchasing futures as opposed to the underlying is the ability to earn interest on the cash collateral (the risk free interest rate). Assuming no other costs or benefits, the no arbitrage futures price should simply be the spot price multiplied by the risk free rate of return, compounded until expiration.

$$\text{Futures Price} = \text{Spot} * (1 + \text{Risk Free rate})^{(\text{Time to Maturity})}$$

Of course, for most financial instruments, there are benefits (and sometimes costs) to holding the underlying as opposed to purchasing a derivative. For example, if an investor holds a stock or bond, he receives dividends and interest. As an industrial producer, there may be a benefit to holding commodities in inventory to meet sudden changes in demand (economists call this benefit a convenience yield). To receive this benefit, an industrial producer would have to pay the cost to store the commodity. This is an example of a cost incurred in the spot market, not incurred in the futures market. If we consider benefits and costs as a rate of return (so paying $2 to store $100 worth of oil would be a storage cost of 2%), this gives us a new equation for the futures price compared to the spot price:

$$\text{Futures Price}^{9} = \text{Spot} * (1 + \text{Risk Free Rate} - \text{Benefits} + \text{Costs})^{(\text{Time to Maturity})}$$

Futures in the Portfolio: Speculating and Hedging

Futures contracts can be used both to speculate and hedge. In the context of futures contracts, a speculative position is any position that increases portfolio risk (and hopefully also return). For speculators, futures can be used to cheaply create a leveraged position. Futures contracts can also be used to speculate in markets where it is less practical to hold the underlying. For example, many commodities investors purchase futures contracts instead of barrels of oil and bushels of wheat. Another use of futures markets is to quickly gain exposure to an asset class while building a position in the cash markets over several days. For example, many large mutual funds purchase stocks over several days when they receive cash from investors, so as not to move the market. While this cash sits uninvested, mutual fund managers often purchase equity futures contracts to gain market exposure as they build their stock positions.

[7] Source: CME Group margin rates

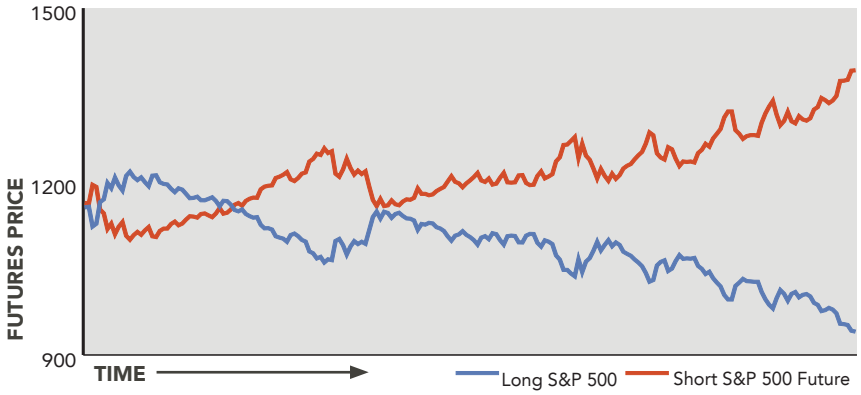
[8] Source: Standard & Poors S&P GSCI FAQ

[9] In reality, models of futures prices assume continuous interest compounding. For a more detailed explanation, see the Appendix.

Futures contracts can also be used to hedge portfolio risks. Just as futures contracts can be used to speculate long or short on currencies, commodities, or financial markets to increase risk, positions in futures markets that offset portfolio positions can be used to hedge and decrease risk. As an example, think of a traditional long only large cap equity portfolio. Because the portfolio is long large cap equities, it is exposed to the risk of a broad equity market decline. If the investment manager believes the risk of a market crash is high, he could offset this risk by entering in a short position by selling an S&P 500 futures contract. Now if the market declines, the equity in the portfolio will decrease in value, but the futures position will increase in value.

This hedging example is illustrated in Exhibit 2.

Exhibit 2: Stylized Hedging Example



Day	S&P	Future	Net
1	2.64%	-2.64%	0%
2	0.33%	-0.33%	0%
3	0.22%	-0.22%	0%
4	-1.75%	1.75%	0%
5	0.61%	-0.61%	0%
6	0.96%	-0.96%	0%
7	1.02%	-1.02%	0%
8	-0.65%	0.65%	0%
9	0.34%	-0.34%	0%

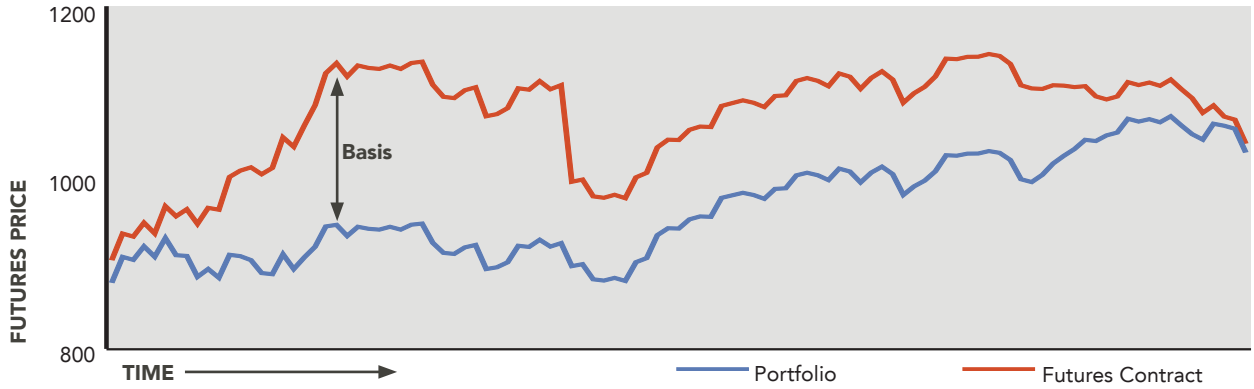
Basis Risk and Imperfect Hedging

While the stylized example in Exhibit 2 shows a perfect hedge (for every 1% decrease in the portfolio, there is a 1% increase in the futures position), in reality most hedges are imperfect. One risk hedgers are exposed to is called *basis risk*. The *basis* is simply the difference between the futures price and the spot price.

Basis = Spot Price – Futures Price

While in theory the futures price is based on the underlying spot price, in practice the futures price can still fluctuate due to market factors. This relationship is shown in Exhibit 3. As the futures contract approaches maturity, it will gradually converge with the spot price. However, in the interim, the basis can change, meaning there may no longer be a one to one relationship between the movements of the portfolio and the futures hedge. As the portfolio increases or decreases, the futures hedge could increase by a smaller or larger amount, causing mark to market losses.

Exhibit 3: Basis Risk



The other risk to hedging with futures contracts is a mismatch between the risk to be hedged, and the futures contract used to hedge that risk. This arises from the fact that there are many more possible portfolio combinations than there are liquid futures contracts. As an example, consider the scenario in Exhibit 2, where the downside risk of a large cap equity portfolio is hedged with an S&P 500 index future. The S&P 500 contract will only be a perfect hedge for the large cap portfolio if the portfolio is an S&P 500 index fund. If the portfolio is, for example, an actively managed portfolio of 20 stocks, the portfolio *will not* be perfectly hedged. Obviously, if the stock market crashes, the value of the 20 stock portfolio will decrease, and the value of the futures contract will increase. However, this relationship will not necessarily be one to one.

Conclusion

Like many financial derivatives, futures are often misunderstood. While they can be used to increase portfolio leverage and risk, they can also be used to manage risk or gain exposure to difficult to invest in asset classes such as commodities. An important take away from the many uses of futures contracts is that they can be appropriate for many different types of investors. In fact, even many conservative investors probably already have some exposure to futures through large mutual funds, which use futures to hedge market risks, or gain market exposure while holding cash positions. Futures contracts are not inherently risky or safe; they are merely an investment tool. What matters is how they are used.

Appendix

Futures prices are considered unbiased estimates of expected spot prices. If this were not the case, arbitrageurs would theoretically be able to earn a riskless profit by purchasing the relatively underpriced asset, and shorting the overpriced one. Assuming all opportunities for riskless profit are quickly arbitraged away, the futures price should be a function of the *expected* spot price at expiration, and the continuously compounded benefits and costs of holding futures. If there are no costs or benefits to owning the asset in the spot market compared to the futures market, the futures price should then be a function of the continuously compounded risk free interest rate earned on collateral as shown in Equation 1:

1. $F = Se^{r(t)}$

Where:

F = Futures Price

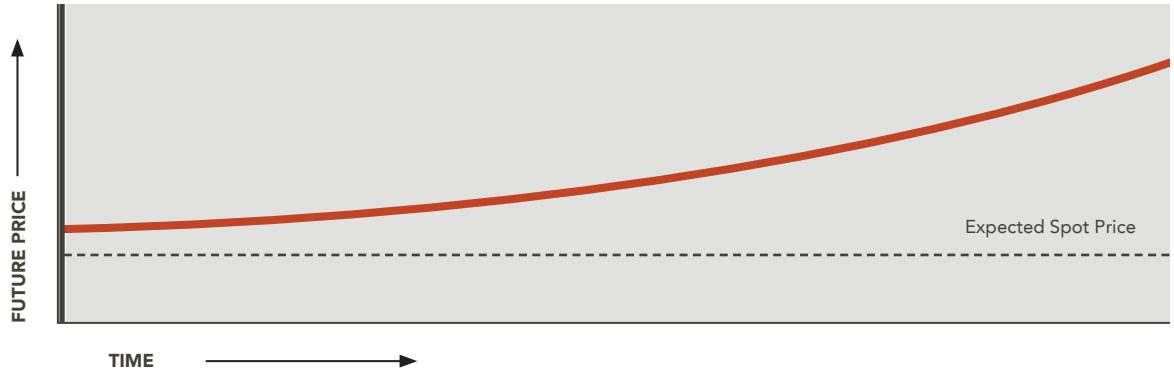
S = Spot Price

R = Risk Free Rate

T = Time to Maturity

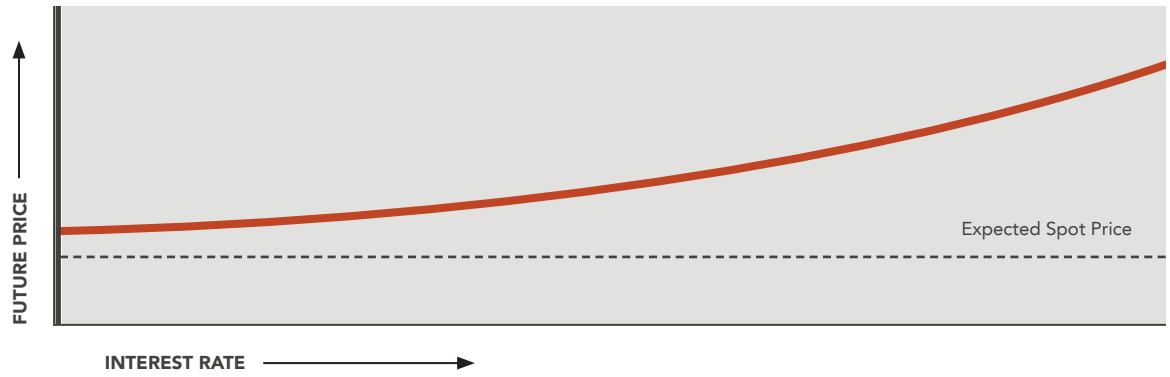
In this case, given a constant interest rate, longer dated futures contracts will be priced higher than shorter dated futures contracts. Stated another way, the longer the time to maturity, the greater the value of the futures contract in relation to the expected spot price. This relationship is shown in Exhibit 4.

Exhibit 4:



Alternatively, given a constant time to maturity, the higher the interest rate, the higher the futures price in relation to the expected spot price as shown in Exhibit 5.

Exhibit 5:



For many futures contracts, there are other differences between holding the futures contract and owning the underlying. For example, purchasers of S&P 500 futures contracts do not receive dividends from the stocks that make up the S&P 500. Therefore, all else being equal, the futures price will be lower than it otherwise would be due to the dividend yield as shown in Equation 2:

2. $F = Se^{(r - d)(t)}$

Where:

F = Futures Price

S = Spot Price

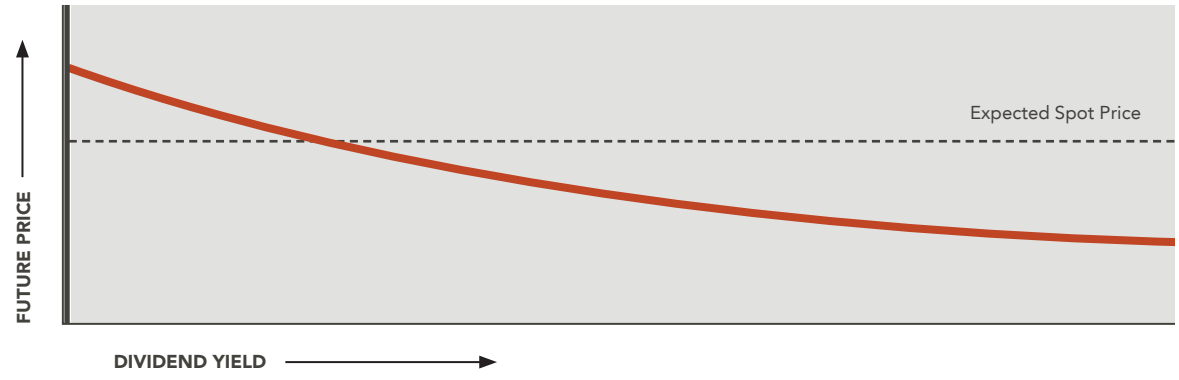
R = Risk Free Rate

D = Continuous dividend rate

T = Time to Maturity

More generally, any benefit due to the owner of the underlying not received by the holder of the futures contract should lower the futures price in relation to the expected spot price. In the case of equity futures, holding all other factors equal, the higher the dividend yield, the lower the futures price in relation to the expected spot price as shown in Exhibit 6. Notice that if the dividend yield on the S&P 500 is greater than the risk free rate, the price of the futures contract should actually be less than the expected spot price in the future.

Exhibit 6:



While benefits to the holder of the underlying asset such as dividends decrease the futures price in comparison to the expected spot price, costs to the holder of the underlying asset increase the futures price in relation to the expected spot price. This is a factor in commodities markets. Both the owner of physical barrels of oil and the owner of an oil futures contract have a future claim on oil, however, the owner of physical oil must pay to store it. Therefore, the value of the futures price should increase with storage costs as shown in Equation 3:

3. $F = Se^{(r + c)(t)}$

Where:

F = Futures Price

S = Spot Price

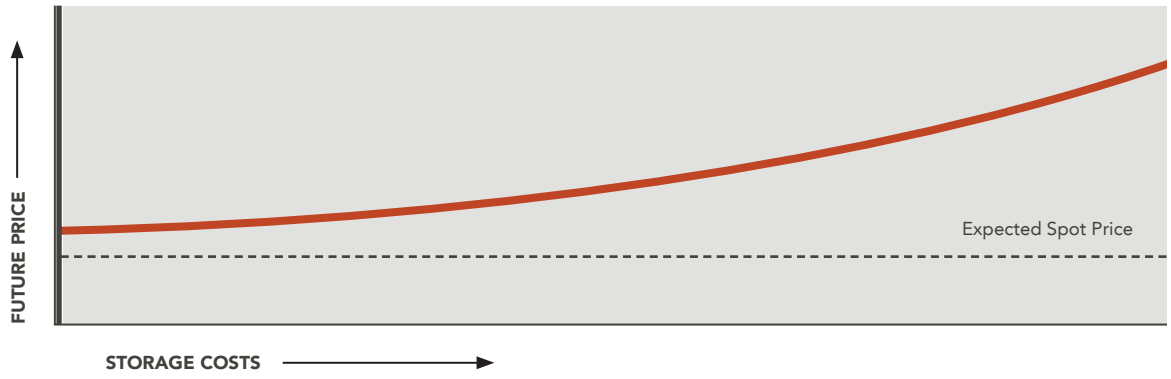
R = Risk Free Rate

C = Storage Costs

T = Time to Maturity

The relationship between the price of an oil futures contract and storage costs is shown in Exhibit 7. Given a constant risk free rate and maturity, the futures price should theoretically start higher than the expected spot price. As storage costs increase, it becomes increasingly more advantageous to hold the futures over spot commodities.

Exhibit 7:



While the example in Exhibit 7 illustrates the costs of holding spot commodities, there can also be benefits to holding spot commodities. The value of the benefit of owning physical commodities is referred to as the *convenience yield*. Importantly, this "yield" is only available to the end users of commodities and not to speculators as it is a production benefit. In the case of oil for example, if inventories are low, or if there is a temporary supply shortage, there may be a benefit to owning physical barrels as an end user in order to take advantage of temporary price dislocations or to keep factories running. For this reason, convenience yields are considered to be inversely related to inventory levels. As the convenience yield is a benefit conferred to the holder of a spot commodity, the value of the corresponding futures contract should decrease as the convenience yield increases as shown in Equation 4:

4. $F = Se^{(r + c - y)(t)}$

Where:

F = Futures Price

S = Spot Price

R = Risk Free Rate

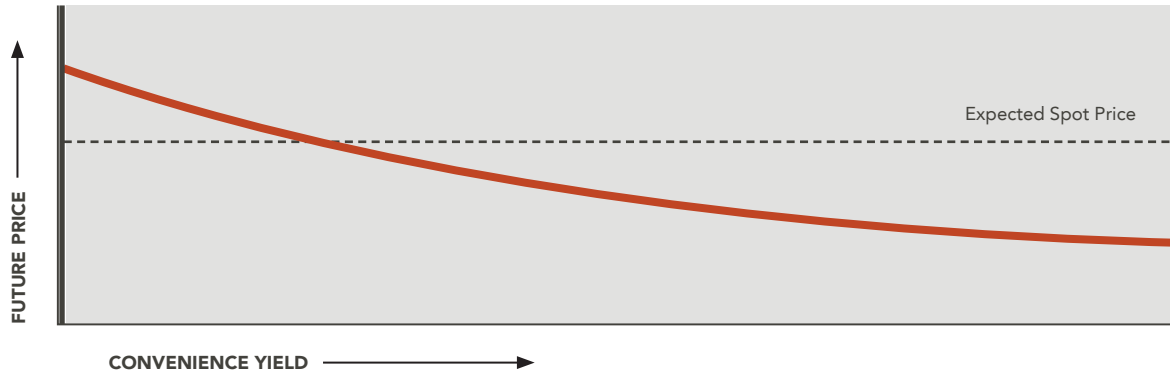
C = Storage Costs

T = Time to Maturity

Y = Convenience Yield

The relationship between futures price and expected spot price for an oil futures contract is shown in Exhibit 8, holding all factors constant except for the convenience yield. As the convenience yield increases, the futures price in relation to the expected spot price decreases. If the benefit from the convenience yield is greater than the risk free rate and storage costs, the futures price should be lower than the expected spot price. If the futures price is lower than the expected spot price due to a convenience yield this will not be corrected by arbitrage, as it is impossible to short spot commodities.

Exhibit 8: Oil Futures Contract



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